CONSTRAINING THE EVOLUTIONARY HISTORIES OF SPIRAL DISKS

M. Mollá and E. Hardy

Universidad Autónoma de Madrid,Cantoblanco (Spain)

and

National Radio Astronomy Observatory (NRAO)[1]

RESUMEN

Estudiamos el conocido problema de la unicidad de los modelos de evolución química. Habíamos demostrado en Mollá et al. (1999) que con los modelos multifase se podían reproducir las distribuciones radiales observadas de los índices espectrales Mg2 y Fe52 para tres galaxias de Virgo. Dichos modelos, sin embargo, pueden ajustar las distribuciones radiales observadas para el tiempo presente con diferentes historias de formación estelar (Tosi 1996). Los dos índices espectrales sufren a su vez la llamada degeneración edad-metalicidad, que impide discriminar al mismo tiempo la edad y la metalicidad de las poblaciones estelares simples. Trataremos ambas cuestiones analizando un conjunto de modelos multifase para la galaxia de Virgo NGC 4303

ABSTRACT

We study the old problem of the uniqueness of chemical evolution models. We showed in Mollá et al. (1999) that multiphase models for three Virgo cluster galaxies were able to reproduce the observed radial distributions of spectral indices Mg2 and Fe52. But those models may fit the present-epoch radial distributions with different star formation histories (Tosi 1996). The two spectral indices above are in turn affected by the well known age-metallicity degeneracy which prevents the disentangling of age and metallicity for single stellar populations. In this work we face both issues by analyzing a set of multiphase models for the Virgo galaxy NGC 4303.

Key Words: **GALAXIES: ABUNDANCES – GALAXIES: EVOLUTION – GALAXIESL SPIRAL – GALAXIES: STELLAR CONTENT**

1. INTRODUCTION

In this work we compute a large number of multiphase chemical evolution models for the Virgo galaxy NGC 4303. This model has been widely described in Ferrini et al. (1994); Mollá et al. (1999). A protogalaxy is assumed to be a spheroid composed of primordial gas with total mass $M(R)$. For NGC 4303 the rotation curves obtained by (Distefano et al. 1990) and (Guhathakurta et al. 1988) are used to compute $M(R)$. The galaxy is divided into concentric cylindrical regions 1 kpc wide and the model calculates the time evolution of the halo and disk components belonging to each one. The halo gas falls into the galactic plane to form the disk, which is a secondary structure in this scenario, at a rate f. This infall rate f is inversely proportional to the collapse time scale τ_{coll}, which, in turn, is assumed to depend on galactocentric radius as: $\tau_{coll} = \tau_0 \exp{(R - R0)}/\lambda_D$, where the characteristic time scale τ_0 is determined using the total mass of the galaxy, through the expression (Gallagher et al. 1984):

$$\tau_0 = \tau_{MWG}\left(\frac{M_{9,MWG}}{M_{9,gal}}\right)1/2 \qquad (1)$$

Stars form out in the halo, by a Schmidt law, while in the disk stars form in two steps: molecular clouds c form from the diffuse gas by a Schmidt law, $c = \mu g^{1.5}$, then cloud-cloud collisions produce stars by a spontaneous process, at a rate proportional to H: $SFR \propto Hc2$. The efficiencies or probabilities to form molecular clouds and stars, ϵ_μ and ϵ_H respectively, are assumed as dependent on morphological type T (see Mollá et al. 2002). The other two efficiencies corresponding the other processes described are assumed constant for all halos and galaxies.

2. THE COMPUTED MODELS

We must now select these input parameters (τ_0,λ_D and T) for this galaxy. In order to take into account the uncertainties in their selection, we choose them over a wide range of values. We thus run models with 5 values for the characteristics collapse time scale: $\tau_0 =1$, 4, 8, 12 and 16 Gyr. We

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[1]The National Radio Astronomy Observatory is a facility of the National Science Foundation operated under cooperative agreement by Associated Universities, Inc., U.S.A.
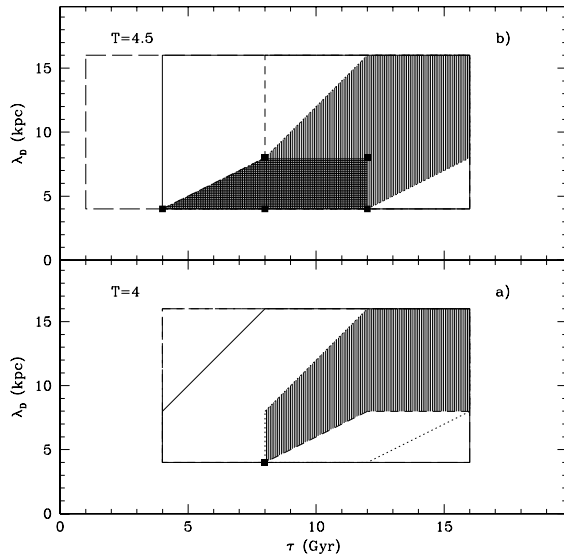
Fig. 1. Probability contours representing regions with P≥ 97.5 % for all observational constraints for T= 4 (panel a) and T= 4.5 (panel b) as a function of τ and λ.

also assume 5 possible values for the scale length: $\lambda_D =$1, 4, 8, 12 and 16 kpc. On the other hand, if we change the collapse time scale values, the efficiencies –or equivalently T –must be changed accordingly, in order to reproduce the observed radial distributions which are the same used in (Mollá et al. 1999). We assume that T take values from 1 to 20. We thus run a total of 500 models with all possible variations of these three parameters, τ_0 , λ_D and T.

3. THE χ^2 OPTIMIZATION

We estimate the goodness of fit for these 500 models with the statistical indicator χ^2 (see Mollá & Hardy 2002 for details). First, by choosing those models able to fit the present-time observational constraints with probabilities larger than 97.5 %, we find only 19 valid models among the 500 initial ones.

Next, radial distributions of Mg2 and Fe5270 are computed, by using the chemical abundances and star formation histories predicted by the above selected chemical evolutionary models as the necessary input for the synthesis procedure which calculates spectral indices.

We use again the statistical indicator χ^2 to compare these predicted spectral indices distributions with the data and thus to select the adequate evolutionary histories over the disk. Only 6 models are able to fit the spectral indices radial distributions with the same level of confidence of 97.5%.

We reduce, therefore, the possible star formation histories to those predicted by the models whose parameters fall within a very restricted range: $4 < T < 4.5$, $4 < \tau_0 < 12$ and $4 < \lambda_D < 8$. This may be clearly seen in Fig.1, where the regions with probabilities higher than 97.5% for all observational constraints are shown as the zones shaded with horizontal and vertical lines for $T = 4.5$ (panel b), while for $T = 4$ (panle a) there is only one point ($\tau_0 = 8$ Gyr, $\lambda_D = 4$ kpc)

4. CONCLUSIONS

- When spectral indices are used these 19 possibilities reduce to 6. The spectrophotometrical information is essential to select the adequate star formation histories.

- Our technique of mixing both evolutionary chemical and synthesis models proves a very useful tool which might be applied to other kind of galaxies or galaxy regions.

- We suggest that radial measurements of spectral indices on spiral disks must be consider seriously in the preparation of observing programs.

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M. Mollá: Departamento de Física Teórica C-XI, Univerisdad Autónoma de Madrid, Campus de Cantoblanco, 28049-Madrid Spain (mercedes.molla@uam.es).

E. Hardy: National Radio Astronomy Observatory (NRAO), Casilla 36-D, Santiago, Chile (ehardy@nrao.edu).